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Interactive comment on "Shallow landslides modeling using a particle finite element model with emphasis on landslide evolution" *by* Liang Wang et al.

Liang Wang et al.

liang.wang2@unibo.it

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We thank the Anonymous Referee #1 for his constructive comments. Liang Wang on behalf of all Co-Authors.

GENERAL COMMENTS:

(1) RC1: "The use of PFEM is not new in Landslide simulation"

AC: Agree. From the perspective of computational mechanics, PFEM is a widely used numerical strategy. However, in a geological approach, the efforts trying to link slope stability and landslide run-out analysis are of great interest to geotechnical and geo-

logical researchers. Recent studies can be found in e.g., Material Point Method (MPM) [1-2], Smoothed Particle Hydrodynamics (SPH) [3].

(2) RC1: "Model a 3D problem with a 2D method"

AC: The chosen case of the Cà Mengoni landslide was studied in a previous paper[4] by other authors with a 2D model to investigate stability analysis since most geotechnical data were acquired after the landslide occurrence only along a longitudinal transect. 2D models are indeed common practice even today[5]. So far, very few studies are conducted to cover the entire evolution of landslides, As for the 3D applications of PFEM to landslides [6-7], they are limited to the dynamic aspect (run-out analysis), which is usually done by using depth-averaged models.

(3) RC1: "Modeling a long duration landslide…"

AC: The model mainly presents the response of landslide geometry to the parameters in the framework of PFEM. The results indicate the existence of an intrinsic weakening process, which can provide the time evolution of the geo-material behavior. So far, we are not able to fully simulate this process since there are no observation data.

(4) RC1: "The first case is quite simple and the use of PFEM is questionable"

AC: The shallow failure mode has also been produced by other numerical methods, e.g. SPH[8] and MPM[2]. The whole computational configuration is similar to the experiment of the collapse of aluminum bars [9,10]. As for the question on remeshing and mapping, Figure 5 in the literature [10] (concerning the dam break problem) shows that the frequency of mapping doesn't play a significant role in such case. We will add a section to discuss the remeshing and mapping applied to the dynamic evolution of the slope.

(5) RC1 :"…., an extended revision is suggested"

AC: Accepted. In the submitted version of our paper, we didn't explain PFEM in detail especially in the explanation of the PFEM for solid mechanics.

SPECIFIC COMMENTS

(1) RC1: "The authors should explain more clearly which are the novelties of the work and why the work is worth to be published."

AC: We investigated the application of PFEM to the whole process of the landslide motion from inception to the end and used a real case, for which few studies have been conducted. We will explain it better in revision.

(2) RC1: "The works of Salazar (2016) and Cremonesi (2011) on landslides simulation with the PFEM should be referenced."

AC: We will add them.

(3) RC1: "Re-mapping operations are used in the PFEM only when historical variables are used and stored at nodes. This is not done in the classical (and most used) PFEM approach, which is generally used for ïňĆuid dynamics problem. Indeed, the PFEM for solid mechanics has been used only in a few works (J.M Carbonell, X.Zhang, W. Zhang and co-workers). This is not a weak point of the method at all, but it should be mentioned in the introduction."

AC: We will explain better the use of the mapping technique in PFEM solid and its accuracy.

(4) RC1: "The description of the PFEM is poor. It is not even mentioned how tessellation is built (I guess Delaunay Triangulation as in the standard PFEM). In this sense, Figure 2 is not clear and does not help to understand the method (the initial mesh is identical to the discretization after remeshing, so why remeshing?)."

AC: A detailed procedure will be added.

(5) RC1: "The explanation of remapping operations is not clear, and, again, Figure 2 does not help the understanding. Furthermore, from the picture, it seems that three integration points are used in the ïňĄrst mesh, and only one in the new one. Which

elements are used? Linear or quadratic? This choice should be also motivated."

AC: We will explain the mixed triangular element we use and the procedure for mapping. We graphed only one new point to explain, but in fact mapping is done for all integration points. A clearer text will be put after figure.

(6) RC1: "Some considerations about the effect of remeshing over stresses accuracy should be included."

AC: The communication between historical variables, e.g. stress, at gauss points from old elements to new elements induces errors, which are however always minimized by reducing the time step. We will discuss it based on our present simulation.

(7)-(8) RC1: "The case 1..."

AC: Agree. Following the suggestion, we will remove Case 1.

(9) RC1: "All the section is a bit confusing and it is hard to follow and understand the motivation of the several tests done by the Authors. Furthermore, as already said previously, the accuracy of the numerical results cannot be clearly assessed."

AC: Our aim here was to investigate the difference between dynamic analysis and static analysis based on a real case in relatively simple conditions. The simulations are done to capture some dynamic process of the landslide based on the whole process simulation. We will improve the texts and figures in the revision. As for the accuracy, the whole computational configuration is similar to the experiment of the collapse of aluminum bars[9, 10].

TECHNICAL CORRECTIONS AND TYPOS:

Accept all and will be modified in the revision.

REFERENCES:

[1] Liu X, Wang Y, Li D Q. Investigation of slope failure mode evolution during large

deformation in spatially variable soils by random limit equilibrium and material point methods[J]. Computers and Geotechnics, 2019, 111: 301-312.

[2] Yerro A, Alonso E E, Pinyol N M. Run-out of landslides in brittle soils[J]. Computers and Geotechnics, 2016, 80: 427-439.

[3] Li L, Wang Y, Zhang L, et al. Evaluation of Critical Slip Surface in Limit Equilibrium Analysis of Slope Stability by Smoothed Particle Hydrodynamics[J]. International Journal of Geomechanics, 2019, 19(5): 04019032.

[4] Berti M, Bertello L, Bernardi A R, et al. Back analysis of a large landslide in a flysch rock mass[J]. Landslides, 2017, 14(6): 2041-2058.

[5] Yerro A, Soga K, Bray J. Runout evaluation of Oso landslide with the material point method[J]. Canadian Geotechnical Journal, 2018 (999): 1-14.

[6] Cremonesi M, Ferri F, Perego U. A basal slip model for Lagrangian finite element simulations of 3D landslides[J]. International Journal for Numerical and Analytical Methods in Geomechanics, 2017, 41(1): 30-53.

[7] Franci A, Cremonesi M. 3D regularized μ (I)-rheology for granular flows simulation[J]. Journal of Computational Physics, 2019, 378: 257-277.

[8] Peng C, Wu W, Yu H, et al. A SPH approach for large deformation analysis with hypoplastic constitutive model[J]. Acta Geotechnica, 2015, 10(6): 703-717.

[9] Bui H H, Fukagawa R, Sako K, et al. Lagrangian meshfree particles method (SPH) for large deformation and failure flows of geomaterial using elastic–plastic soil constitutive model[J]. International Journal for Numerical and Analytical Methods in Geomechanics, 2008, 32(12): 1537-1570.

[10] Zhang X, Oñate E, Torres S A G, et al. A unified Lagrangian formulation for solid and fluid dynamics and its possibility for modelling submarine landslides and their consequences[J]. Computer Methods in Applied Mechanics and Engineering, 2019, 343:

314-338.

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